PUB-75-155-E
E-0252

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Some Features in Rapidity Space of Multiparticle Production by Proton-Proton Collision at 102 GeV/c

by

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This is a study of multiparticle production induced by the proton-proton collision at 102 GeV/c. As to the multiparticle production due to the hadron-hadron interaction, many works have been done. Through these elaborated works, it has become much more convincing that the multiparticle production goes through some intermediate states called frequently as cluster[1~4]. To make clear the nature of this clustering, many works have been done also. However, it is still unsolved and one of the most important problems in the multiparticle production.

Recently, a charge transfer between two groups of charged particles divided by the forward-backward hemisphere in the center-of-mass system for the proton-proton collision is studied and shown that the transfered charge between them is mostly neutral[5]. In this work, a charge transfer at the maximum gap of the rapidity space is studied, that is, charge transfer at the gap where the difference of the rapidity between neighbouring charged particles in each event is maximum and it is found that the transfered charge at the maximum gap is mainly neutral.

The analysis is done using the 3K pictures of the 30" liquid hydrogen bubble chamber film taken at the Fermi National Accelerator Laboratory. The nominal momentum of the proton is 102 $\pm$ 1 GeV/c. The scanning is made twice to detect the events of all topologies induced by the incident proton. The detection efficiency evaluated from this double scanning is 99.4 percent. The total number of events detected is 1290, among which 1009 events have 4 or more prongs. The total cross section for 1290 events is 38.1 $\pm$ 1.6 mb.

For each charged particle, the rapidity, η, is assinged and lined up in every event according to its magnitude as,

$$\eta_1 < \eta_2 < \cdots < \eta_i < \cdots < \eta_{n_c}$$

where n_c is the charged multiplicity. The rapidity is evaluated using the relation, $\eta = -\ln \tan\frac{\theta}{2}$, where θ is the emission angle of the charged particle in the laboratory system. The maximum gap in the rapidity space is defined as, at this gap, the difference of the rapidity, $\Delta\eta_i = \eta_{i+1} - \eta_i$, has the maximum value denoting as $\Delta\eta_{max}$. In Fig.1, the distribution of the gap number i at which the maximum gap of each event is observed is shown separately in prong number. In this figure, the maximum gap whose $\Delta\eta_{max}$-value satisfies the condition of $\Delta\eta_{max} > Y/n_c$ is employed. The Y means the total width of the rapidity space. The total width depends on the total energy of intereaction and on the transverse masses of secondary particles under consideration. Moreover, empirically it depends also on the multiplicity. In this analysis, a relation, $Y = -\frac{5}{14}(n_c - 4) + 10$, is used. This relation is derived using the results of the present analysis, that is, the rapidity distribution for each charged multiplicity for the 102 GeV/c proton-proton collision. As shown in Fig.1, the maximum gap is likely to appear at the gap number i = 1 or n_c-1 where the gap number i means the gap with $\Delta\eta_i = \eta_{i+1} - \eta_i$. This tendency holds even in relatively high multiplicity.

In Fig.2, the correlation between the positions of the first and the second maxima among the rapidity gaps in each event, that is, the correlation between i_{max} and i_{2nd}, is shown. In Fig.3, the

correlation between the rapidity differences at these two gaps, $\Delta\eta_{max}$ and $\Delta\eta_{2nd}$, is given. In Fig.2, the correlation between i_{max} and i_{2nd} is not recognized. In this figure, only the events with $\Delta\eta_{max} > Y/n_c$ are adopted. In Fig.3, all of the events (without any limitation to $\Delta\eta_{max}$-value) are used. According to the multiperipheral model, the spacing of the rapidity is expected to be nearly equal, that is, $\Delta\eta_{max} \simeq \Delta\eta_{2nd}$. Fig.3 does not support this prediction.

In Fig.4, the distribution of charge transfer, ΔQ, at the maximum gap is shown. Dotted lines in the figure represent the results calculated by a random (uncorrelated) distribution of the rapidity. The hypothesis of the short-range order gives also approximately the same results. It is confirmed, moreover, that the phase space calculation in which the t-cut (t is the squared four-momentum transfer of the leading particle) and the contribution of π^0 by the charge independence are taken into account gives consistent results with those calculated by the random distribution. In Fig.5, the correlation between the charge transfer, ΔQ, and the first maximum gap number i_{max} is shown. It is clearly seen that, at $i_{max} = 1$ or n_c-1, $\Delta Q = 0$ is enhanced. Therefore, it can be stated that the experimental distribution of charge transfer at $i_{max} = 1$ or n_c-1 has a strong peak at $\Delta Q = 0$. Such a feature is seen at the 28.5 GeV/c proton-proton interaction. This is shown in Fig.6.

The authors would like to thank professor T. Ferbel of the University of Rochester and Drs. J. R. Sanford and T. Yamanouchi of the Fermi National Accelerator Laboratory for their kind help

to make the present analysis feasible. Thanks are due also to the bubble chamber group at Brookhaven National Laboratory for their courtesy by which we have the bubble chamber film exposed to the 28.5 GeV/c protons.

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Figure Captions

Fig.1. Distribution for the maximum gap number, i_{max}, where the rapidity difference between neighbouring charged particles in the rapidity space shows the maximum.

Fig.2. Distribution for the number of events, each of which has the first maximum at the gap number, i_{max}, and the second maximum at i_{2nd}.

Fig.3. Distribution for the number of events with the rapidity differences of $\Delta\eta_{max}$ for the first maximum and of $\Delta\eta_{2nd}$ for the second one.

Fig.4. Distribution for charge transfer, ΔQ, at the maximum gap.

Fig.5 Correlation between charge transfer, ΔQ, and the maximum gap number, i_{max}. The distributed numerical values represent the number of events.

Fig.6. Correlation between charge transfer, ΔQ, and the maximum gap number, i_{max}, for the proton-proton interaction at 28.5 GeV/c. The distributed numerical values represent the number of events.

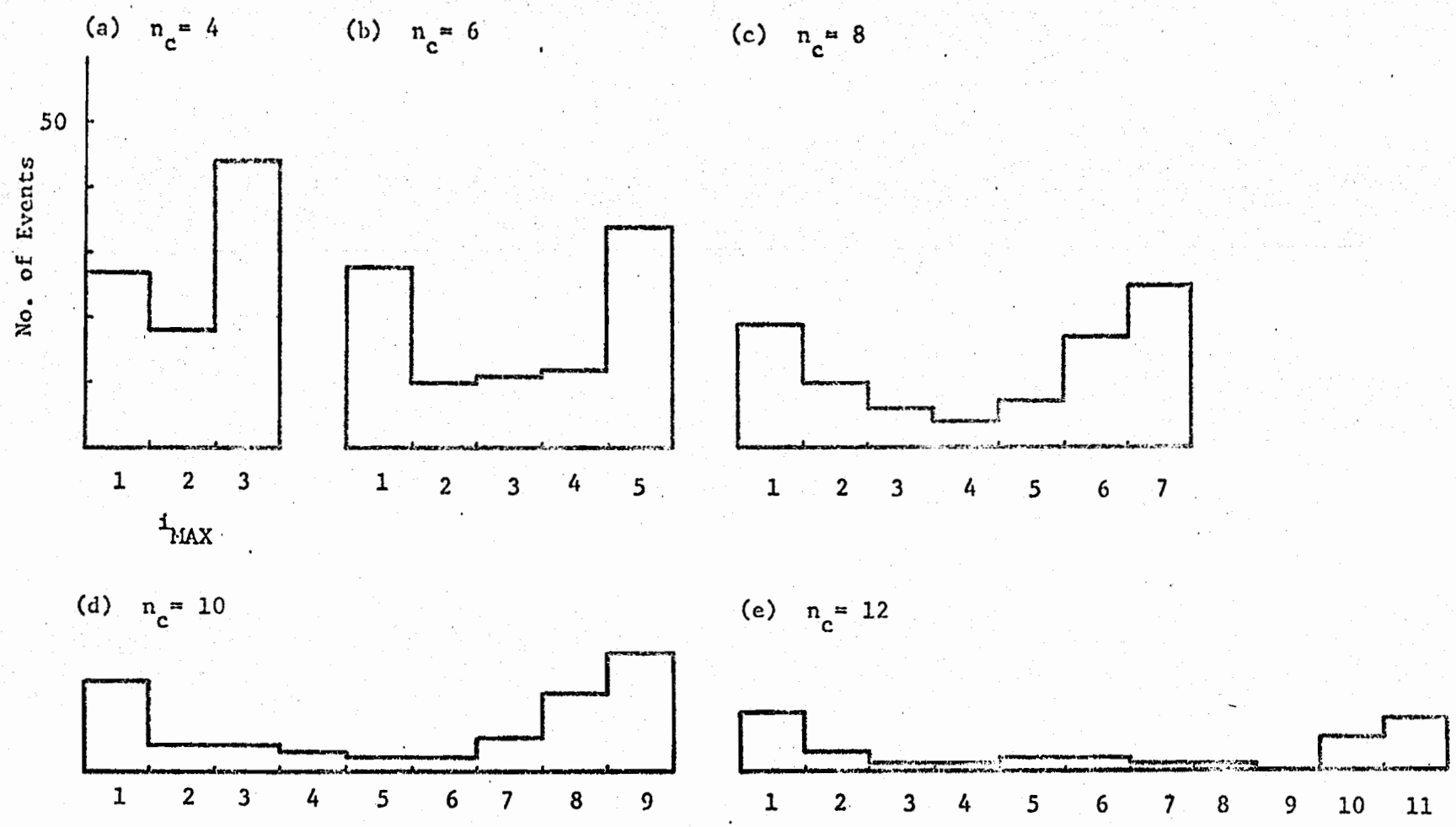
(a) $n_c = 4$
(b) $n_c = 6$
(c) $n_c = 8$
(d) $n_c = 10$
(e) $n_c = 12$
No. of Events
50
1 2 3
i_{MAX}
1 2 3 4 5
1 2 3 4 5 6 7
1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8 9 10 11

Fig. 1

(a) $n_c = 4$

i_{2nd} \ i_{MAX}	1	2	3
1		9	25
2	17		19
3	10	9	

(b) $n_c = 6$

	1	2	3	4	5
1		4	1	5	11
2	9		2	3	10
3	6	4		1	6
4	6	2	2		7
5	7	1	6	3	

(c) $n_c = 8$

	1	2	3	4	5	6	7
1		2	3	2	3	5	6
2	3				2	1	6
3	3	2			1	3	3
4	2	2	1		1	2	2
5	1		1	2		1	3
6	3	1					5
7	8	3	1			5	

(d) $n_c = 10$

	1	2	3	4	5	6	7	8	9
1		3	2	1			3	7	6
2	2			1				1	4
3	2								1
4					1			2	
5	1							1	3
6									1
7	3					1		1	1
8	4	2		1	1	1			2
9	4		2		1		2		

Fig. 2

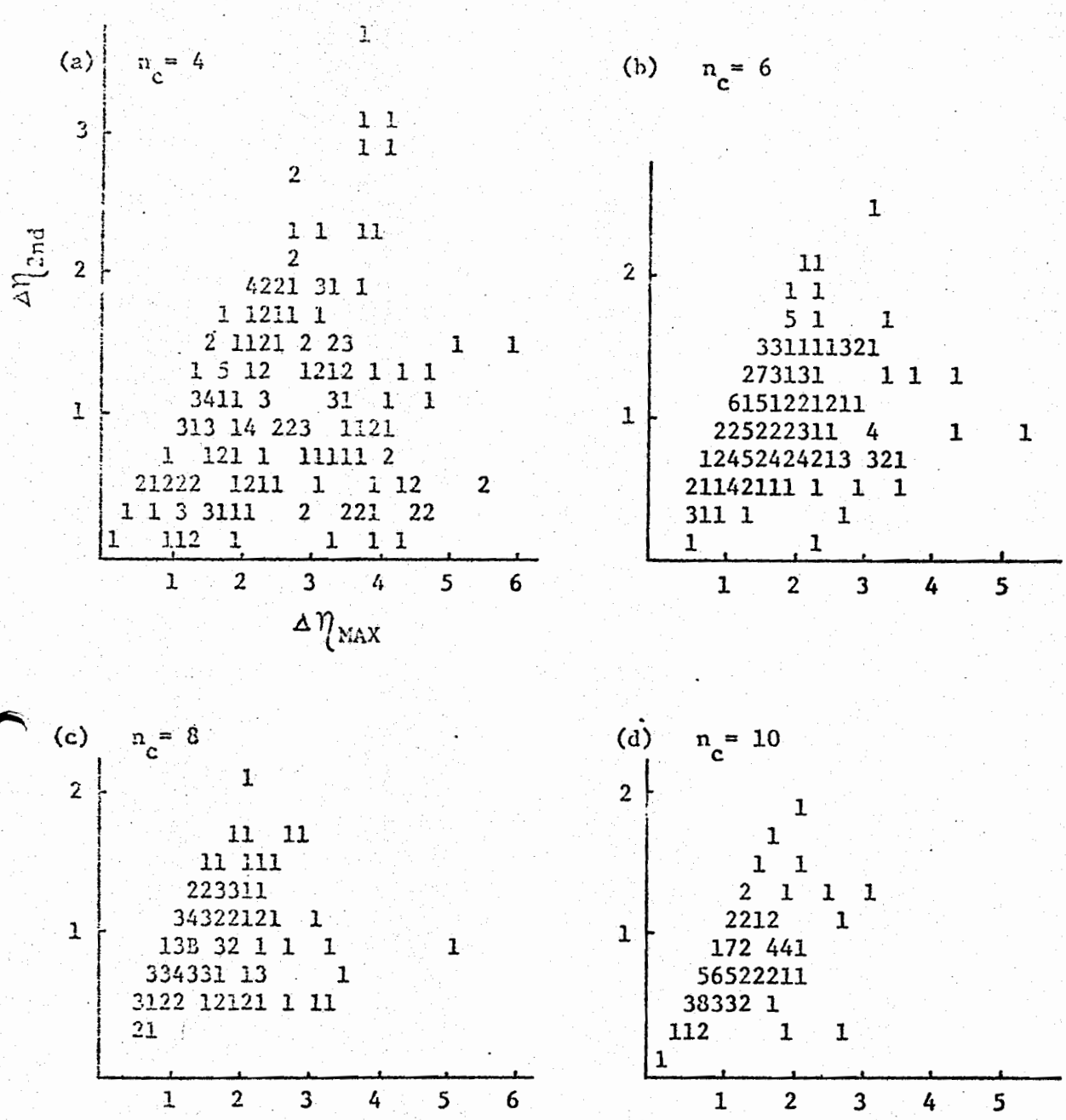

Fig. 3

Figure 4 is missing.

(a) $n_c = 4$

i_{MAX}	−2	−1	0	+1	+2
1	1		26		
2		12		6	
3			44		

(b) $n_c = 6$

	−2	−1	0	+1	+2	+3
1	4		24			
2		5		5		
3	1		9		1	
4		7		4		1
5			34			

(c) $n_c = 8$

	−2	−1	0	+1	+2	+3
1	1		18			
2		8		2		
3	3		2		1	
4		3		1		
5	1		6			
6		9		7		1
7			21		4	

(d) $n_c = 10$

	−3	−2	−1	0	+1	+2
1		2		12		
2	1		1		2	
3		2		2		
4	1		2			
5				2		
6			2			
7		1		4		
8			4		8	
9				8		10

charge transfer ΔQ

Fig. 5

(a) $n_c = 4$

i_{MAX}	-2	-1	0	1	2
1	10		65		
2		30		11	
3			163		

(b) $n_c = 6$

	-2	-1	0	1	2
1	9		50		
2		18		7	
3	3		13		1
4		18		14	
5			87		13

(c) $n_c = 8$

	-3	-2	-1	0	1	2	3
1		18		21			
2	1		10		2		
3		1				1	
4			1		1		
5		3		7			
6			3		8		1
7				35		11	

(d) $n_c = 10$

	-2	-1	0	1	2
1			9		
2		4			
3			1		
4		1			
5					
6				1	
7					2
8		2			
9			7		2

charge transfer ΔQ

Fig. 6